NORTHEASTERN FOREST EXPERIMENT STATION

Semiannual Report
Watershed Management Research

April 1, 1968 - September 30, 1968

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NE-1601 - WATER YIELD IMPROVEMENT, Durham, New Hampshire

Standardizing Notation for Energy and Water Balance Equations

As we discuss the radiation budget, the energy balance, and the water balance in our talks and papers, the lack of standardization of terminology and notation becomes evident. Table 1 shows the notations used in the most useful recent texts by Slatyer, Sellers, Veihmeyer (in Chow), Munn, and Geiger.[1/] We think that Forest Service watershed scientists, at least, could agree on using a standard notation, so Table 1 also includes a proposed standard notation as a starting point for discussion.

Several points need further comment:

1. Solar and thermal radiation are the preferred names as they indicate the original source and thus the wavelength range. Shortwave and longwave are only relative terms and could be confused with radio terminology. Infrared is ambiguous as there is near infrared included in the solar radiation. Terrestrial is not much used and to some people connotes only R_{tu} and not R_{td}.

2. Several other radiation terms have not been included since they are less commonly used, e.g. the separation of the solar beam (direct) and solar diffuse (sky, hemispherical) parts of R_{sd}, potential insolation, and clear sky radiation.

3. Use of the general term "subsurface" heat flux, S, instead of soil heat flux is necessary to include the many other materials of interest, e.g. snow, water, city buildings, and vegetation.

4. M for both metabolism (photosynthesis minus respiration) and snowmelt should not be confusing and is often convenient.

We invite comments regarding the need for standardization and the proposed notations.

[1/] Geiger, R. 1965. The climate near the ground. Rev. ed. Harvard Univ. Press, Cambridge, Mass.

Munn, R. E. 1966. Descriptive micrometeorology. Academic Press, New York.

Sellers, W. D. 1965. Physical climatology. Univ. of Chicago Press, Chicago.

Slatyer, R. O. 1967. Plant-water relationships. Academic Press, New York.

Veihmeyer, F. J. 1964. Evapotranspiration. In Chow, V. T. ed. Handbook of Applied Hydrology. McGraw-Hill, New York.

Table 1.--Notations Used in Energy and Water Balance Equations

Term	Proposed	Slatyer	Sellers	Veihmeyer	Munn	Geiger
Net radiation	R_n	R_n	R		Q_N	S
Downward solar rad.	R_{sd}	R_s	Q+q	Q_s	Q_T	I+H
Reflected solar rad.	R_{su}	rR_s	a(Q+q)	Q_r	Q_R	R
Downward thermal rad.	R_{td}		$I\downarrow$		$Q_{L\downarrow}$	G
Upward thermal rad.	R_{tu}		$I\uparrow$		$Q_{L\uparrow}$	σT^4
Net thermal rad.	R_{tn}	R_l	I	Q_b		
Evaporation (heat)	LE	lE	LE	Q_e	Q_E	V
Evaporation (mass)	E	E	E	E	E	V
Sensible heat flux	H	H	H	Q_h	Q_H	L
Subsurface heat flux	S	G	G	Q_θ	Q_G	B
Metabolism	M	aA				
Snowmelt (heat)	L_fM					
Snowmelt (mass)	M					
Precipitation	P	P	r	I		N
Streamflow	F	O	Δf	O		A
Deep seepage	G	U				
Soil water change	ΔW	ΔW	g	S		

Precipitation-Streamflow Comparisons for Southfacing Watersheds

As a prelude to preparing calibration equations for Hubbard Brook Watersheds 4, 5, and 6, comparisons of precipitation and streamflow were made for all six southfacing watersheds. Figure 1 shows mean annual values and rankings for the pretreatment years in which data overlapped for all watersheds.

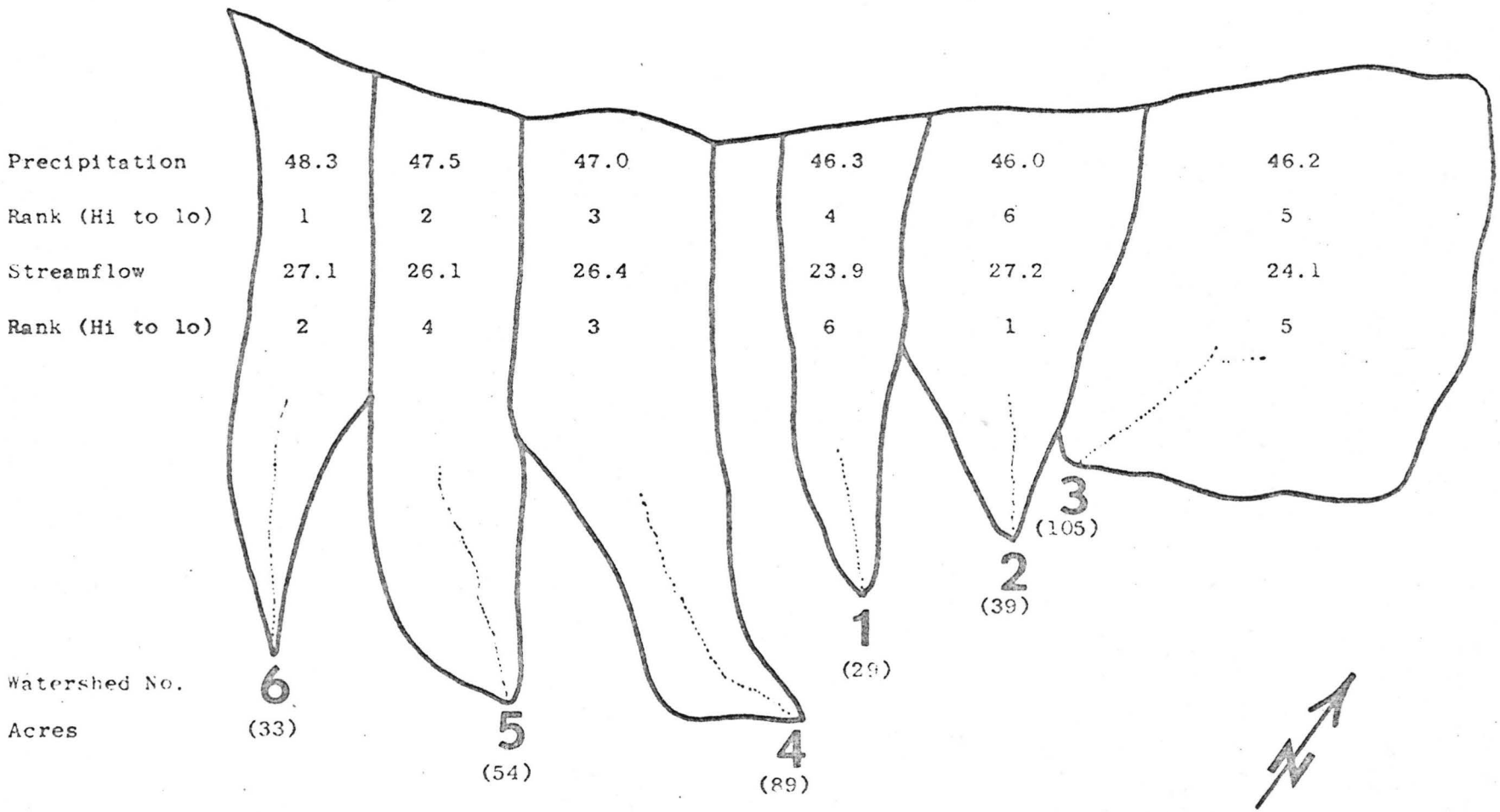
Mean annual precipitation decreases by more than 2 inches from the westernmost to easternmost watersheds. The decrease has been consistent since start of record collection despite the fact that the overall distance across the six watersheds is only slightly over 1 mile. Summer storms frequently deposit widely varying amounts on the watersheds but the summer differences appear to be randomized as there is little orographic stratification in annual catches by individual gages. The major storm direction is from the northwest so that it would appear that all watersheds should receive about equal precipitation. All of which is to say that we have no explanation for the between watershed precipitation differences.

The range in mean annual streamflow values is 3.3 inches. Since the Hubbard Brook drainage is underlain by a tight bedrock, losses to deep seepage cannot be used to explain away the inconsistencies between watersheds. It would appear that some of the differences may be due to boundary location, especially since adjacent Watersheds 1 and 2 have the lowest and highest mean streamflow values. But the possibility that the watersheds naturally flow differently because of physical factors such as soil depth, drainage patterns, slope, etc. is not being overlooked.

Although the absolute between watershed streamflow differences are small, a seismic survey of soil depth to bedrock is being considered to provide an insight into the watershed differences.

Herbicide Treatments on Clearcut Watershed

For the third summer in a row an herbicidal spray was required to treat persistent stump sprouts in our clearcut watershed. Bromacil (80% in water at 25 lbs./A) was broadcast via helicopter the first summer, and 2,4,5-T (4% of 4 lbs. AE in water) was mist blown on all sprouting stumps and other volunteer vegetation the next two summers. Although we readily recognize that more potent and less costly chemicals are available, a principal factor in the selection of these herbicides is to limit as far as possible the chance for contamination. Water quality measurements are a vital part of the study; thus the introduction of additional ions into the watershed via herbicides might upset existing nutrient inflow and outflow relationships. The stumps of some species have an unusual capacity to withstand repeated herbicidal treatments but we can see signs that they are beginning to weaken. The most persistent and vigorous species is white ash followed by beech, sugar maple, and finally yellow birch--our four major forest trees.



NE-4

Fig. 1. Precipitation and streamflow rankings with respect to watershed location.

During the course of monitoring the stream for possible release of the herbicides from the watershed, some interesting observations came to light. For the first 2 weeks after application, the concentration of bromacil was about 1 ppm. After 1½ years, the concentration was .25 ppm and the total amount of bromacil leaving the watershed through the stream was 207 lbs.--20% of the total application.

At the beginning of the second summer, extensive growth of algae was observed in the stream channel. Although care was taken not to spray 2,4,5-T in the close proximity of the stream, the algae all but disappeared shortly after the initiation of spraying. Whether the 2,4,5-T caused the algal subsidence is unknown but the concentration of "T" in the stream was less than .1 ppm.

--R. S. Pierce
C. A. Federer
J. W. Hornbeck

NE-1602 - FLOODS AND WATER YIELD, Parsons, West Virginia

More on Inexpensive Labor

Strictly observed personnel ceilings coupled with reduced budgets make most of us scratch hard to maintain planned research schedules. This summer, we could not have kept 120 acres of two experimental watersheds vegetation-free or maintained our weirs, rain-gage openings, and service trails without extra help. With conventional hiring prohibited, we turned to the College Work Study Program (see our previous semi-annual report). Last April we found 2 Davis and Elkins College students out of school for lack of funds. They worked from then until this fall. Before the summer was over we had 2 more students from Davis and Elkins and one each from West Virginia University and Fairmont State College. All of these boys were willing and capable workers on arduous and sometimes unpleasant tasks. Some of them hope to come back next summer; one is thinking of changing his major to forestry. Of course, there was one who lasted 2 days; the work is demanding physically.

This program has 2 vital advantages: (1) the students are college, not Forest Service, employees and (2) we pay only $.30 per hour for their services. Our crew of 6 good men was paid a total of $1,102.90 for a little over 3 crew-months work, about the starting salary of just one GS-2. The Office of Economic Opportunity, through the employing college, paid the remaining 80% of their salaries. One last point--it is legal to issue these students a Forest Service driver's license and this adds much to their usefulness.

Now our project clerk has resigned to accompany her husband out of state and she cannot be replaced conventionally. A college Work Study student is possible but awkward with school in session. Now we are dealing with the local Office of Economic Opportunity to obtain a girl to work 4 days per week and go to school on the 5th day. She too will not count as an employee and, best of all, the Office of Economic Opportunity pays her entire salary.

Local authorities are anxious to place these people in good work environments and these programs should be as helpful to other watershed researchers as to us. Perhaps these programs have not been used elsewhere simply because we in West Virginia have so many more of them than less privileged parts of our country.

Evaporation Pan Studies at Parsons

Since 1963, evaporation pans have been exposed in 3 sites at Parsons. The earliest was observed for 2 years in an 80-foot grassy opening surrounded by hardwoods about 25 feet high. The second, operated 1963-1967, was in a 40-foot opening surrounded by hardwoods 40-50 feet tall. Both openings faced about south on 10 percent slopes. In 1965 a conventional Class A weather station was established in a large, flat, grassy area near the laboratory. Although there were no periods of common observation, some comparisons between the pans were made by Niranjan Goswami, an A.I.D. trainee from India.

Evaporative loss always was greatest at the laboratory weather station, least at the small forest opening. Statistical tests showed these results significant at the 5% level. Evaporative losses from the pan in the large forest opening did not differ significantly from pan loss in the small opening or at the weather station. The largest daily evaporative loss observed was 0.33 inch at the weather station. Daily loss rarely exceeded 0.28 inch and 0.25 inch was considered a larger-than-normal daily loss.

Table 1 summarizes all of the available data to focus more sharply on how size of opening influenced evaporative losses. The growing season at Parsons, May through October, includes all the months when forest trees draw water and nutrients from the soil. Note that size of openings had little effect on evaporation before leaves had fully opened in May. It is often said that microclimate in the leafless hardwood forest differs little from that of open fields. In May, then, evaporation in both forest openings differed little from that at the weather station. However, during the balance of the growing season, evaporation in the small opening surrounded by hardwood trees in full leaf was only about two-thirds that at the weather station. Evaporation in the large opening consistently held midway between these extremes. After leaf emergence, largest losses from all pans occurred during the long, hot days of June and July. Decreasing heat and day length toward autumn was clearly reflected by decreasing evaporation from all pans.

Table 1.--Influence of pan exposure on evaporative loss during the growing season

Month	Average daily evaporative loss (inch)		
	Weather station	Large opening	Small opening
May	0.17	0.17	0.16
June	.19	.16	.14
July	.19	.16	.13
August	.15	.13	.11
September	.13	.11	.09
October	.09	.07	.06

Table 2 shows remarkable agreement among several methods for estimating evaporative loss. Penman's equation provided theoretically sound estimates differing less than 1/2 inch per month from measured evaporation during most ice-free months. Estimates of potential evapotranspiration by Thornthwaite's method agreed within 1/2 inch with 70% of pan evaporation except for months of July and August. This close agreement among measured and calculated evaporative losses suggests that the Parsons weather station pan provides the estimates closest to true values for this important measure of climate. It emphasizes the importance of exposing instruments under standard conditions, an especially important consideration in forest microclimate studies.

Table 2.--Comparison of several methods for estimating evaporative losses. Based on long-term average climatic data from the Parsons weather station

Month	Penman	Weather station pan	Weather station pan X 0.7	Potential evapotranspiration
	---------Inches---------			
April	2.47	2.87	2.01	1.87
May	5.81	5.02	3.51	3.25
June	5.85	5.94	4.16	4.08
July	6.02	5.78	4.05	4.62
August	5.69	4.82	3.37	4.19
September	3.94	3.83	2.68	3.01
October	2.12	2.71	1.90	1.55
Total	31.90	20.97	21.68	22.57

--James H. Patric

An Inexpensive Substitute for 2,4,5-T?

This past spring found us confronted with the problem of having 120 acres to maintain vegetation-free and no herbicides available to do the job. After a thorough search and several unsuccessful attempts to purchase 2,4,5-T we decided upon using Brush Killer 155, manufactured by Amchem Products Incorporated. It contains 1 lb. 2,3,6-TBA, 1.0 lb. 2,4-D and 0.75 lbs. 2,4-DP per gallon. The Brush Killer was recommended to be less volatile and safer than other herbicides available to us.

The manufacturer recommends a mix of 2 gallons of Brush Killer 155 (total of 5.5 lbs. acid equivalent or ae) to 100 gallons of water applied at a rate of 400 gallons of mix per acre (22 lbs. ae per acre). Several factors prohibited our following the recommendations. First, it is too time consuming to apply 400 gallons of mix to an acre. Second, ground cover on these watersheds isn't as heavy as that covered in the recommendations. Third, and most important, our budget just wouldn't allow spending $44.00 per acre for herbicides (8 gal. @ $5.50 per gal.).

We experimented a little to find a more suitable mix. Initially we applied a mix of 2.5 gallons to 100 gallons of water at a rate of 130 gallons per acre (8.9 lbs. ae per acre). This was not strong enough. Mixing 11.25 quarts of herbicide in 100 gallons of water with the same application rate (130 gal. per acre, 10.0 lbs. ae) produced quick wilting with a satisfactory kill. We used this mix over most of the area. Six or seven acres of dense growth on Upper Watershed 6 were sprayed with a mix of 3.75 gallons herbicide in 100 gallons of water at an application rate of about 160 gallons per acre (16.5 lbs. ae per acre). This produced an 85% kill as of the last survey but some vegetation was still dying at that time.

A small area (25 acres) was sprayed with a 2,4-D and Brush Killer 155 mixture and provided an excellent standard with which the Brush Killer could be compared. Two and one-half gallons each of 2,4-D and Brush Killer 155 were mixed with 100 gallons of water and applied at a rate of 160 gallons per acre (35.0 lbs. ae per acre) on the dense growth in Upper Watershed 6. Generally this produced quicker, more complete kills than the 16.5 lb. application of Brush Killer 155 alone but the residual effect of the strong Brush Killer mix may over-come the difference in initial kill.

In the past we have used a mixture of 2,4-D - 2,4,5-T mixing 2.5 gal. of each with 100 gallons of water (25 lb. ae per 100 gallons of water). Applying this solution at the same rate (160 gal. per acre, 40 lb. ae per acre) would probably have produced quicker and apparently better kills than the above but it has little persistent effect. Perhaps the best measure of this point will be when we observe sprouting next spring.

We do feel however, that a mix of 5 gallons of Brush Killer per 100 gallons of water would be as effective as the 2,4-D - 2,4,5-T mixture if applied at the same rate. The Brush Killer is somewhat less effective on greenbrier than the 2,4-D - 2,4,5-T but it was very effective on the predominant fire weed and on the few coniferous species we sprayed.

Cost is a very important factor. Brush Killer 155 costs $5.50 per gallon in 55 gallon drums. 2,4-D (6 lb. aeg) costs $3.28 and 2,4,5-T (4 lb. aeg) costs $5.50 per gallon. The cost per acre for the 2,4-D - 2,4,5-T mix (40 lb. ae per acre) is $35.12. Applying the Brush Killer in a 3.75 gallon mix at the same rate (16.5 lbs. ae per acre) costs $33.00 per acre, but, as stated, this mixture may be somewhat less effective. The comparable mixture of Brush Killer recommended by the manufacturer (5 gallons per 100 gallons of water) would cost $44.00 per acre for chemicals. These figures are for the maximum application rates whereas 80 percent of the area was sprayed with the 11.25 quart mix of Brush Killer (8.9 lbs. ae applied per acre). This cost an average of $17.78 per acre. Applying a 2,4-D - 2,4,5-T mix at our normal rate of 130 gallons per acre (29 lbs. ae per acre) costs $28.50 with a slightly better kill. We probably can slightly increase the amount of Brush Killer applied and do the job more cheaply and just as effectively as with the 2,4-D - 2,4,5-T mixture. We feel that 4.38 gallons of Brush Killer per 100 gallons of water applied at a rate of 130 gallons per acre (15.6 lbs. ae) would be as cheap and as effective as our normal 2,4-D - 2,4,5-T solution.

Erosion on Devegetated Watersheds

For several years (since 1964) halves of two gaged watersheds have been kept void of vegetation by use of herbicides. Besides the problem of obtaining herbicides, we also have the problem of somewhat unstable soil. Generally, either soil movement or deposition is clearly evident over both devegetated watersheds. Pedestals can be observed as much as 1-inch tall. Most of this material moves only a short distance and is either intercepted by slash or else deposited in low places. To date little sediment has been monitored in the streamflow.

Preliminary results from the first two years of sampling in the humus study on the lower half of Watershed 7 (cut in 1967) indicate that there is a large initial loss of organic matter and roots in the surface soil. This loss, with increased surface heating, has caused a distinct breakdown in the original crumb structure of the A horizon. Our logging superintendent clearly states what's happening in non-technical terms; he says the soil on these devegetated watersheds has no "life" when he goes over it with the bulldozer. In essence there is very little left to hold the soil together and it is starting to erode. We can expect, however, that the surface slash piles and low points will keep the soil from going very far for a while--but for how long?

--Charles A. Troendle

Field work was started on a study this spring at the Fernow Experimental Forest to provide information on root distribution in forest types and soils common in West Virginia. Root profiles are exposed on strip-mine walls and road cuts, both less than two years old. The number and size of roots per square foot is being recorded to maximum rooting depth. Other records include cover type, soil type, stand age, stand density, root cavities and profile characteristics.

Preliminary results indicate that Ernest soil, characterized by a clay pan and mottling, contains fewer roots than the lighter textured Dekalb soil (Figure 1). Roots do not grow as deep in Ernest soils as in Dekalb soils. This seems particularly true in the northern hardwood forest type.

In the cove hardwood type also, light textured soils have the most roots (Figure 2). Preliminary results indicate that the light textured Dekalb has the most roots and the heavy textured Belmont soil has the least with the medium textured Gilpin in between.

Cover type also influenced root distribution (Figure 3). Preliminary results indicate that the northern hardwoods are the shallowest rooted with little difference between the oak-hickory and cove-hardwood forest types. About 90% of the northern hardwood roots were in the top two feet of soil while 75% of the roots in the other two cover types were in the first two feet of soil. Roots were rarely found below four feet in northern hardwoods or below six feet in other forest types. Roots larger than 1/4-inch in diameter and root cavities were seldom observed below the 30-inch depth.

The maximum rooting depth observed during this study was 12 feet and it occurred under the oak-hickory cover type. It appears that soil moisture sampling to a depth of 4 feet under the northern hardwood cover type, and 6 feet under other cover types, would account for most of the moisture use by plants in this area. Similar studies will have to be made in other areas to determine if these results are applicable because of the many factors which affect root distribution. These data will be subjected to statistical analysis when the study is completed.

--James N. Kochenderfer

FIG. 1--Northern hardwood root distribution with soil depth. The numbers in parenthesis are the number of profiles taken in each soil.

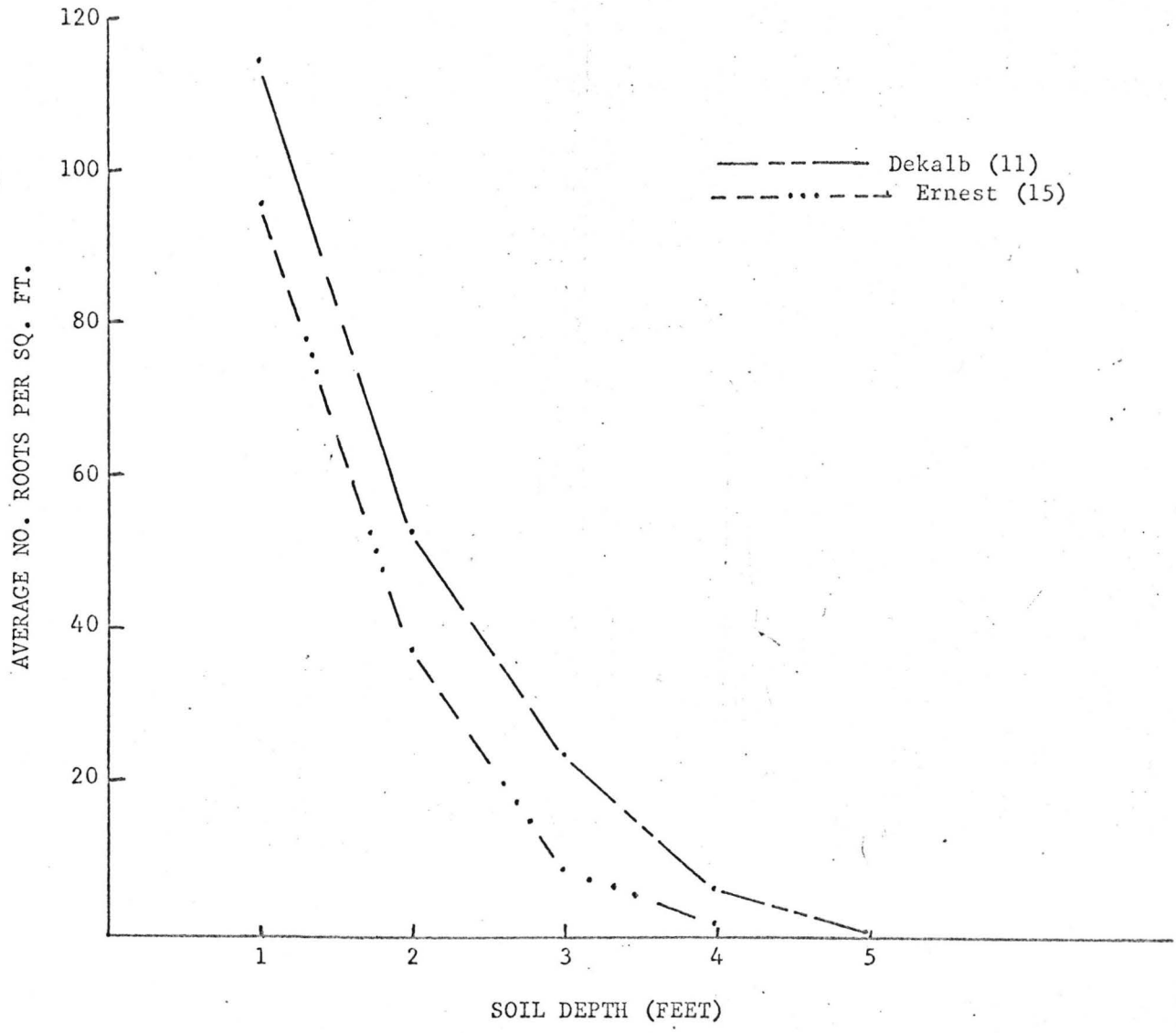


Figure 2.--Cove hardwood root distribution with soil depth

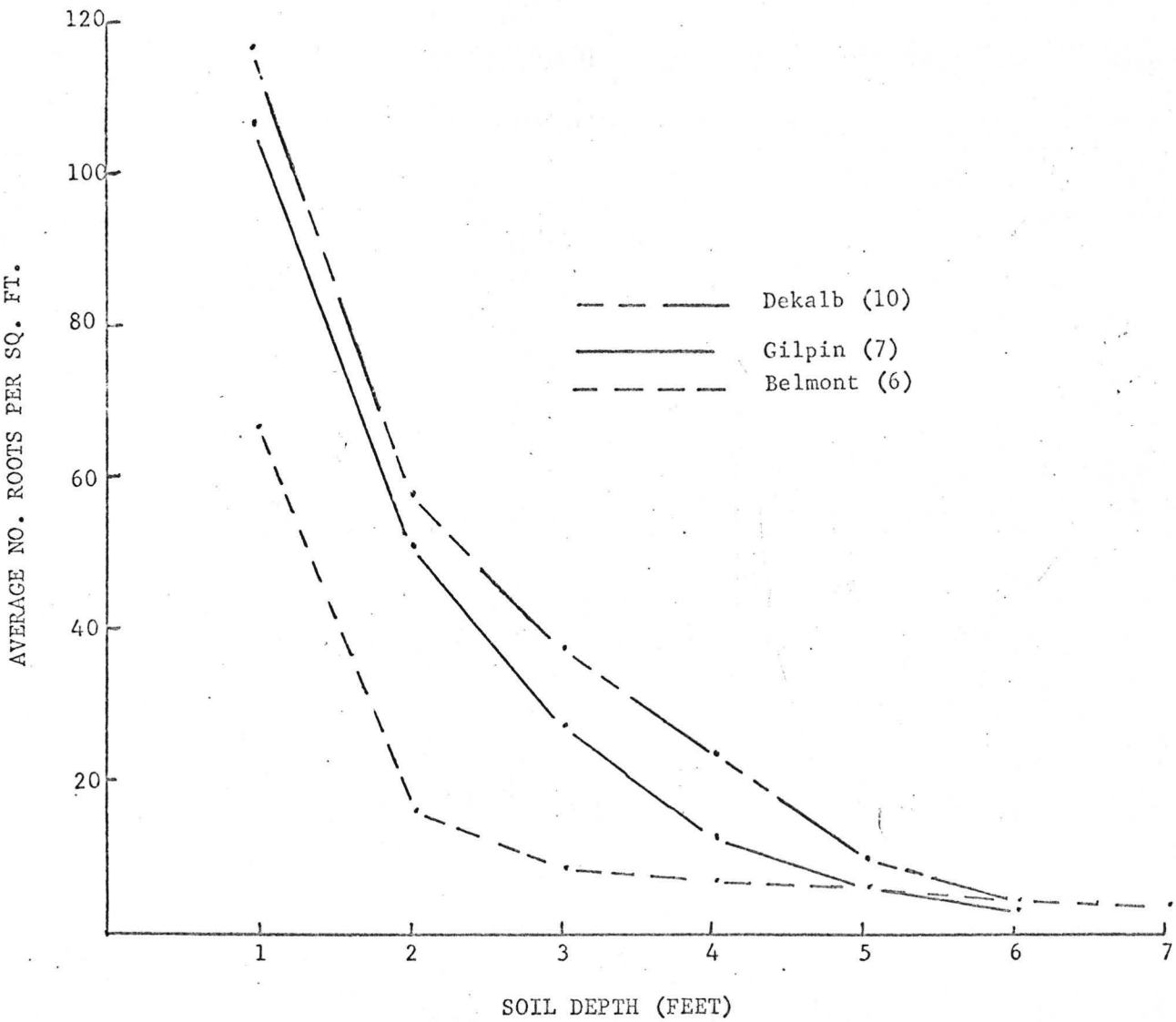
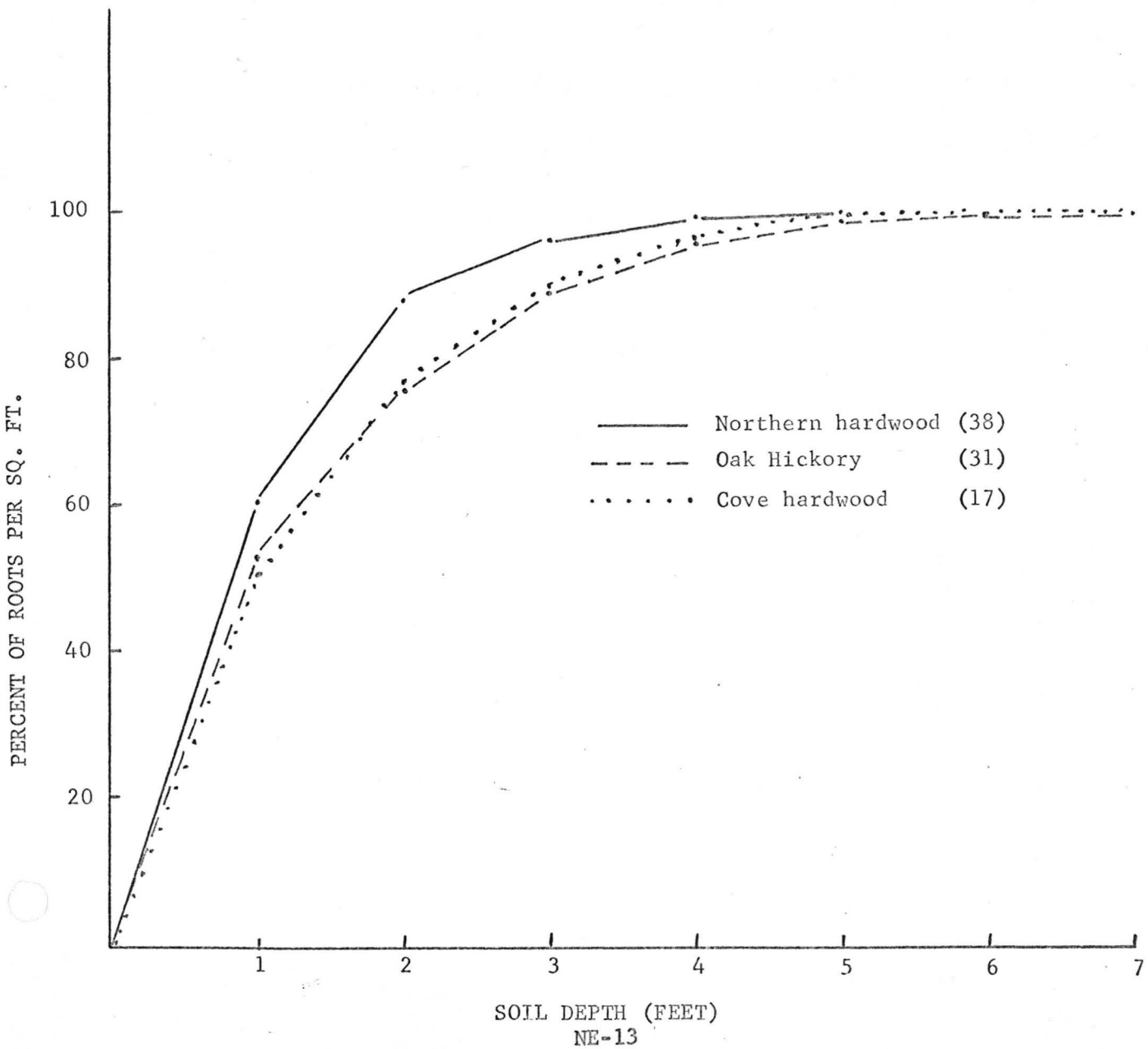


Figure 3.--Root distribution with soil depth expressed as a accumulative percentage of the total for three cover types



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NE-1603 - FOREST HYDROLOGY AND URBAN FOREST ENVIRONMENT

Upper Darby, Pennsylvania

Municipal Watersheds

The municipal watershed questionnaire study is now in its final stages. A follow-up letter was sent to all water surveyors who did not respond to the original questionnaire. We have had replies from approximately 75 percent of the 1200 addressed which include city water departments, water authorities, water districts, private water companies, State Parks, State Forests, and National Forests.

We are continuing the installation of treatments on municipal watersheds this year. At our Baltimore Cooperative Watersheds this fall we plan to remove 50 percent of the remaining white pine-loblolly pine plantation from Watershed No. 1, which has already had the riparian zone cut. At Newark No. 1 we are widening the riparian clearcut from 20 feet each side of the stream to an area encompassing all land within 5 feet in elevation of the stream channel. At our Penn State Cooperative Watersheds, Bill Sopper last year cut the lower one-third of Leading Ridge Watershed No. 2, a mixed oak-hardwood forest about 50 years old. All woody stems were cut and sprouts sprayed with 2,4,5-T. Plans are to hold this treatment for 2 years, cut the middle one-third of the watershed and hold for two years, and finally cut the upper 1/3 and maintain the clearcut condition for two years.

--E. S. Corbett

Regional Studies

We devoted most of our efforts to preparing two manuscripts. One, John Hewlett, In defense of experimental watersheds, answers five recently published criticisms of the value of experimental watersheds in hydrologic research, and cites advantages of, alternative to, and contributions of experimental watersheds. Water Resources Research may publish it.

Considerably more time was spent in roughing out a manuscript Forest and floods: A reconsideration, a proposed companion to last year's Station Paper Increasing water yield in the Northeast.... We hope to send review copies by Christmas.

In abeyance are analyses of the hardwood humus data collected in our regional study with Don Mader, further analysis of trends in the long-time streamflow records that we and Art Eschner are studying, and our major study of eastern-forest streamflow with Bill Sopper.

--H. W. Lull
K. G. Reinhart

Solar Radiation Relationships

In a previous semi-annual report, the aerial tramway system used by this project to obtain information on temporal and spatial variation of albedo was mentioned. Some data from the system in the hardwood stand is presented in Table 1. This tramway is 100 feet long, 65 feet high, and about 10 feet above the general plane of the canopy.

Sound Propagation

A literature review and a preliminary field investigation on the propagation of sound in the forest has produced some early information. From the literature, it is noted that stands of trees attenuate about 8 decibels per 100 feet of depth. Differences between species do not appear to be large.

A list of common sounds measured with a General Radio Model 1551-6 Sound Level Meter is presented in Table 2.

Table 1.--Albedo at solar noon - cloud free sky conditions.

Date	Incident Solar Radiation Ly/Min.	Albedo	Canopy Condition
1968			
April 26	1.36	0.11	No leaves
May 24	1.22	0.12	Leaves starting
June 27	1.26	0.16	Full leaf
Aug. 22	1.29	0.16	Full leaf
Sept. 12	1.10	0.15	Full leaf
Oct. 23	0.80	0.14	No leaves

Table 2.--Intensity at the source of some common sounds

Item	Decibels
Jet aircraft	140+
Express train	100
Car horn	110
Chain saw	100
Construction equipment:	
20 ton crane	102
125 PSI compressor	98
Dog barking	92
Busy intercity highway	72-78
Typing pool	72
Busy office	52
Normal speech	48

Environmental Laboratory

A root investigation was inaugurated at the College of Forestry - Northeastern Forest Experiment Station Cooperative Environmental Laboratory near Warrensburg, New York.

Roots of a 35-year-old red pine in a plantation planted at 6- X 6-foot spacing are currently being exposed by hand digging of the deep sand. Excavation starts from the stump of the 8-inch dbh, 51 foot high tree that weighed 350 lbs., dry weight total of needles, branches, and bole. The roots from the main sample tree and all other red pine roots in the area encompassed by the sample tree roots are being collected separately, by 5 diameter size classes, from a 2- X 2-foot grid system, in the 0-7 inch AP horizon, 18-inch B, and at one foot depth intervals below the soil solum. This excavation will cover the entire soil volume into which the roots of the 8-inch dbh sample tree extend.

--R. E. Leonard

NE-1605 - FOREST RESTORATION OF STRIP-MINED LANDS, Berea, Kentucky

General

In April, a two-day conference between the staffs of the Northeastern Forest Experiment Station and the Soil Conservation Service was held in Quicksand and Berea, Kentucky. The main theme of the meeting was strip-mine revegetation.

Those participating were:

U. S. Forest Service

R. D. Lane, Director, Northeastern Forest Experiment Station, Upper Darby
W. T. Doolittle, Asst. Director, Northeastern Forest Experiment Station, Upper Darby
Grant Davis, Project Leader, Berea
W. G. Vogel, Range Scientist, Berea
W. T. Plass, Plant Ecologist, Berea
W. R. Curtis, Hydrologist, Berea
W. A. Berg, Soil Scientist, Berea

Soil Conservation Service

S. L. Tinsley, Director, Northeastern Regional Technical Service Center, Upper Darby
W. W. Steiner, Regional Plant Materials Specialist, Upper Darby
W. B. Bryan, Jr., State Soil Conservationist, Lexington
H. A. Taff, State Conservationist, Lexington
J. D. Ruffner, Plant Materials Specialist, Morgantown
N. A. Colbert, Manager, Plant Materials Center, Quicksand
Wayne Everett, Asst. Manager, Plant Materials Center, Quicksand

Kentucky Department of Natural Resources

Elmore Grim, Director, Division of Reclamation, Frankfort, Kentucky

The group spent one day at the Quicksand Plant Materials Center and one day at Forest Service headquarters in Berea. As a result of the discussions, general consensus pointed up a need for improved cooperation between the two agencies. Some areas suggested for improvement are:

(1) Communication at all levels

(2) Introduction, testing, and development of plant materials

(3) Development of a uniform regional classification system for spoil materials in place and in spoil banks.

During the last week in June the Berea Watershed Management staff attended the Northeastern Forest Experiment Station Research Advisory Council meeting at Pineville, Kentucky. Each staff member presented a resume of his work together with needs for future studies. The entire group made a trip to get a first-hand look at some strip-mining.

Recent personnel changes have resulted in a temporary reduction of the Berea staff. Bill Plass moved to Princeton, West Virginia in August to spearhead some reclamation research there; he is, however, still a member of NE-1605. In July, Bill Berg accepted a position with the Agronomy Department at Colorado State University.

--Grant Davis

Hydrology

Since the last report in March, we have installed a spoil moisture study on area-type stripped land in the Western Kentucky Coal Field. As anticipated we had some problems drilling the holes.

We rented a Model B-30 all-hydraulic rig from Rent-a-Drill Corporation in Indianapolis. First we used 2-inch diameter bits and augers, but after a few holes the diameter was reduced to a point where the access tubing could not be installed. The next size of auger available at the time was 3-inches in diameter. So most of the holes were drilled with this size. After installing the tube, these oversize holes were filled with dry sand. We feel that the sand will have little influence on moisture and density measurements. Even at "field capacity" the small volume of sand would have a negligible influence.

Some of the problems encountered in drilling on the spoil were:

(1) The bit coming to rest on a smaller piece of rock and the rock spinning with rotation of bit.

(2) Bit contacting large pieces of rock at steep angles and deflecting.

(3) Bit going directly in space between two large boulders.

All of the rock was at one time consolidated bedrock, but during the mining process has become pieces of all sizes and shapes with all edges angular. Overall, we experienced less difficulty than we expected. Within a week we put in about 550 feet of access tubing -- 24 to depths of 17 feet and 36 to depths of 4 feet. And this doesn't include "second tries."

The first set of moisture and density measurements have been taken, and the second set is due. For the next report we should have some interesting preliminary statements concerning this study.

Concerning our study of the influence of strip-mining on water values, it appears that chemical quality changes follow mining by 6 to 8 months. The first important change since mining was completed last December came in August when sulfate content increased by three times and pH dropped from 6.9 to 5.7. On the other hand, the stream seems to be clearing up; suspended sediment has dropped from 2,000 ppm to less than 200 ppm over the same period.

Two more of the gaged watersheds are currently being mined. No detailed analyses have been made yet, but it seems that storm peaks have been greatly increased and storm flow durations decreased.

Eastern Kentucky University biologists have made their first in a planned series of surveys of the streams of Leatherwood Creek and Bear Branch to determine the influence of strip-mining on aquatic insects and fishes. The first survey was made prior to any apparent influence of mining, although mining had commenced in the drainage.

This fall we plan to install a study aimed at determining the influence of terracing on runoff and erosion reduction from strip-mine benches.

--Willie R. Curtis

Revegetation

Black locust is the tree species most often planted on steep outslopes of strip-mine spoils in eastern Kentucky. Direct seeding of this tree would be less costly and less difficult than planting. But, obtaining adequate stocking by direct seeding has been uncertain. Preliminary results of a study in eastern Kentucky show that phosphorus is limiting for the growth of direct seeded locust in many spoils. After one growing season, seedlings on plots fertilized with 100 lbs./acre P_2O_5 were 3 to 4 times taller than non-fertilized seedlings. The non-fertilized seedlings averaged about 5 cm (2 inches) tall.

When seeded with herbaceous vegetation and fertilized with N and P, the number of established locust seedlings was, in general, inversely related to the amount of herbaceous cover. But, cover composed mostly of annual ryegrass, a fast maturing cool-season species, reduced the number of locust more than did slower developing K-31 tall fescue or warm-season weeping lovegrass.

The competitive effect of herbaceous cover on growth and survival of newly planted trees is sometimes given as the reason for not seeding a quick cover on mine spoils planted to trees. A study was initiated this past spring in an attempt to quantitatively evaluate the effect of a herbaceous cover of at least 70 percent on the survival and growth of two species of pine and two hardwoods.

--Willis G. Vogel

In the Anthracite Region of Pennsylvania a field study was made in 1965 and 1966 to determine whether crownvetch (Coronilla varia L.) could be established on highly acid coal breaker refuse by planting crowns and using several lime, fertilizer and mulch treatments; and if so, whether the plant would grow well enough to provide quick and effective cover.

Measurements were made after three growing seasons in 1967 and 1968. The data obtained are presented in tabulation below.

The results illustrate clearly that, (a) lime was essential in establishing crownvetch on coal breaker refuse exhibiting pH values below pH 4.0, (b) fertilizer applications and straw mulch treatments were highly beneficial in producing ground cover. After the third growing season, the 1966 planting shows consistently more ground cover than the 1965 planting. This is probably due to the frequent rainfalls during the early periods of the 1968 growing season.

Percent of ground cover produced by crownvetch after three growing seasons

(Average of three replications)

	Lime in tons/acre					
	0		2.5		5.0	
Fertilizer	mulch		mulch		mulch	
lbs./acre	none	straw	none	straw	none	straw
			1965 Planting			
0	0	0	10	20	13	19
250	0	0	12	26	14	20
500	0	0	15	25	15	23
			1966 Planting			
0	0	0	21	34	25	32
250	0	0	28	31	20	28
500	0	0	43	48	48	51

--Miroslaw Czapowskyj

The tubeling study reported in the last semiannual report was established according to plan. A few minor difficulties were encountered in the greenhouse rearing of the tubelings. These, however, could be corrected in a more extensive program of tubeling culture with a routine care and maintenance program. Thus far the tubelings are surviving well in the field plots. Average survival of both species (red and Scotch pine) as of August 21 on all sites was 73 percent. It is still too soon to make any recommendations for the use of tubelings in spoil plantings but early results suggest that tubelings may give acceptable survival on better sites.

Moderate to severe deer browsing was observed on Austrian and jack pine on one of the fall versus spring study areas. Evaluation of this damage suggests that black locust, which was invading the site, influenced the deer browsing. This might be due to the increase in available nitrogen causing more succulent tissue growth which was more attractive to the deer. A note has been prepared on this observation and will be submitted to the JOURNAL OF WILDLIFE MANAGEMENT.

Fifth year height and survival measurements have been completed on the fall versus spring planting study. The results, in general, show that the mortality rate has slowed down considerably except on the very poorest sites, that is, sites having the lowest pH. The plots have been thinned and comparative height evaluations will be made at the end of the tenth growing season.

Data on the sprouting capacity of thinned hybrid poplars have been collected. The data have not been analyzed, but it appears that there is considerable variation in sprouting habit between some clones.

--Walter H. Davidson

NE-1606 - MANAGEMENT OF STORM RUNOFF, Columbus, Ohio

The past six months were spent in developing and executing field studies in hydraulic conductivity of forest soils, planning and conducting an informal, technical symposium of scientists working in the area of root-soil relationships, and in manuscript preparation.

Hydraulic Conductivity of Unsaturated Forest Soils

It appears that from time-to-time during the past eight years we keep coming back to techniques for studying hydraulic conductivity of highly permeable forest soils that have no permanent watertable. Or to be even more specific, soils that may not even be completely saturated (in an areal sense) at any time during the year.

None of the "accepted" field methods we have attempted have proven successful or worthy of further comment. Even so, the water permeability constant is so important where subsurface flow is involved that we have kept looking for methods that might succeed in shallow, permeable forest soils. In 1963, while working on some theoretical equations for radial flow to a ground water well, we roughed out a plan for a plot in which the water level could be regulated. This year we decided the plot idea was worth a try, and several of the Ohio State drainage scientists agreed.

The plot consists essentially of a circular block of soil surrounded by a larger circular tank of water. The water, once the plot is saturated, can be held at an almost constant head level. By drawing the water level down to a specified depth, permeability constants for each horizon or textural layer in the profile can be calculated. That is, we can use either the auger hole drawdown-refill technique or constant pumping discharge rate technique, depending on the permeability of the soil.

We have been working with this constantly since May and are now in the process of getting some encouraging results. Instrumentation, as always, has been a stumbling block. In addition, we find that a fairly permeable soil having a relatively impermeable layer at 36 to 48 inches is preferable in order to minimize seepage losses and to keep the instrumentation, tank size, water used, etc., within the bounds of practicability.

It appears that we have a technique that is usable, and one that will give results in a reasonably short period of time. From the theoretical standpoint, the technique provides a method for checking some of the theoretical equations derived from laboratory and from analog-type simulator trials.

We hope to publish a complete description of the plot and results in the near future.

--R. Z. Whipkey

Root Research

Since my last report, two manuscripts have been prepared. Additional field data have been collected from the soil block exposed last year but these have not yet been analyzed. Many additional "root" references have been obtained and numerous papers reviewed. A root symposium was organized and was held at the Harvard Forest, Petersham, Massachusetts. Work is currently underway to summarize and to compile a mimeographed report of the symposium.

The root symposium was an unqualified success. Thirty-one participants (seven from the NEFES) and ten guests met at the Harvard Forest on August 19-20 and informally discussed various aspects of root research. Unfortunately 45 additional researchers desired to attend but had to be denied permission due to the limited facilities. From the interest in this informal symposium, it is apparent that many researchers are beginning to take a hard look at roots and many others are seeking information on roots and their functions. Rather than go into the details of the symposium, I shall refer you to the mimeographed summary which should be available near the end of October, 1968. There is one point which might be mentioned pertaining to the discussion on the pros and cons of holding future "root" symposia. It was the unanimous opinion that our informal symposium was highly beneficial to all attending. It was also almost unanimously agreed that a larger or more formal symposium would not be as worthwhile, since the major value of this symposium was its broad-based, informal, friendly, off-the-record exchange of findings and ideas. Comments were made that perhaps semi-formal "root" symposia on specific topics could be set up in conjunction with and under the auspices of one or more national societies. It was also suggested that the Gordon Conference might be willing to take on the subject of roots for one of their conferences. These avenues are as yet unexplored.

--G. M. Aubertin

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